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Surgery of the Spine.

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THE SURGERY OF THE SPINE.

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A CASE of spinal tumor operated upon by Mr. Victor Horsley on the 9th of December, 1887 (the diagnosis having been made by Dr. Gowers), and published in the *Medico-Chirurgical Transactions*, attracted the attention of surgeons all over the world. The address of Mr. William Macewen, delivered before the British Medical Association in August, 1888, in which he reported six cases of removal of the posterior arches of the vertebræ with four complete recoveries, all the operations having preceded that of Mr. Horsley, intensified the very wide-spread interest which was already felt, and brought the subject of spinal surgery prominently before the profession. I desire in this paper briefly to review the general outlines of the surgery of the spine, which, I may premise, is not in the least a new subject. To systematise we can divide the cases which may require operative interference into three groups: 1st, Traumatisms; 2nd, Caries; 3d, Neoplasms.

1. Operation in cases of injury was suggested as far back as the days of Paulus Aegineta, who taught that in spinal fracture the surgeon must, if possible, attempt to extract the compressing bone by incisions, having first warned the patient of his danger (Adams' Translation.) Ambrose Paré in the presence of paralysis made a like recommendation. Heister advised removal of any fragment that pressed on the cord. In addition Hildanus, Matz and Vigaroux all referred to the operation, though none of them performed it, while Heine, Roux,



Holscher and Dupuytren each removed portions of the vertebræ for disease. Malgaigne says Chopart and Desault are the first to speak of it as a very simple thing "to trepan between the spinous and transverse processes, to give issue to effused fluids or to elevate or remove pieces of bone which may wound the cord;" but it is not recorded that their suggestions bore any fruit, and a long interval elapsed without further mention of the subject. Dr. James in his "Medicinal Dict.," Lond. 1745, said (in almost the same language employed by Heister):

"If the spinal marrow is wounded, death follows inevitably. Though as it may seem cruel not to attempt the relief of one under these unhappy circumstances, the surgeon should lay the injured part bare by the knife, and elevate the fragments, which press upon the medulla, in a proper manner; or when they are quite loose, extract them in a proper manner; then let him cleanse the wound thoroughly and apply balsamic medicines, using the napkin and scapulary. He must continue this until the wound heals or the patient dies."

The nearest approach to a formal resection of the spine at about this date was the operation of Louis in 1762, reported in the *Arch. Generales de Med.*, vol. xi, 1836, p. 417, and performed upon M. de Villedon, captain in the Regiment of Vaubecourt, who was paralyzed from a gunshot wound of back, received at the battle of Aménébourg. Louis and Duplessis consulted on the third or fourth day. They withdrew fragments of bone.

They also spoke of "the indication for the trephine, even without fracture to give exit to blood, or matter, or even to prevent suppuration in some cases of fracture." M. Villedon recovered and was finally able to walk. Louis concludes, "quoi qu'il en soit c'est une victime que l'art a soustrait à une mort certaine."

The formal operation for the removal of a depressed vertebral arch was, however, first performed by the younger Cline, in the spring of 1814, and though unsuccessful, showed the practicability of such an operation; Cline considered (South's Notes to Chelius's Surgery) that the symptoms sometimes resulted from the pressure of the spinal cord by the spinous

process or arch of the displaced vertebræ, either fractured or not, a condition which he thought analogous to that of the brain when a piece of the skull is driven in upon it and causes symptoms of compression, which are relieved by the removal of the cause of the compression. With this notion he held it feasible to remove the compressing vertebral arch, and so to relieve the palsy. In the clinical lecture which he delivered, he explained the reasons that had induced him to perform this operation, and the grounds upon which he hoped for success.

He considered that in fracture with displacement of the vertebræ, which compressed the spinal cord, this great nervous cord was under precisely the same circumstances as the brain when pressed by fractured skull, and that, therefore, as the elevation of the pressing bone was indicated in the latter case, and often effected with success, so was it equally called for in the former, and that no positive reason could exist why the operation should not be successful, provided the injury of the spinal cord itself were not great, a condition which, as regarded the brain, could equally forbid operation, or render its success improbable or impossible. Before undertaking the operation of cutting out that part of the arch of the vertebra which compressed the cord, Cline proposed to himself the following four questions to which he gave the annexed replies: (1) Will the patient die of the operation? Probably he will, if the injury be severe.¹ (2) If the cord be much hurt will it recover its functions? This is unknown; but we do know that if a nerve be divided it will unite, and the greater part of the spinal cord may be divided in a brute and yet the animal recover; in proof of which he detailed an experiment which he performed on a bitch. (3) After the removal of the arch of the vertebra will the spine be sufficiently strong to support the body? Probably it will for ordinary purposes, though the patient may not be able to lift heavy weights. (4) Will a patient recover from a compound fracture of the spine, which, by the performance of the operation, it becomes? The nearer a fracture is to the source of the circulation, and the less compact, and consequently the more vascular, the bone is, the greater is

¹South says: "I do not exactly understand the answer given, for there is no danger in the operation, if it be performed with care; but I suspect he thought the exposure of the spinal cord might hasten inflammation, and so death might more quickly result."

the probability of recovery. Both these advantages are present in the spine, and therefore favor the successful issue of the case. He added that the only reasonable objection to the operation of trephining the spine is, that we cannot, previous to the operation, ascertain whether the spinal cord be simply compressed, or whether it be partially or entirely torn through, or whether the symptoms of compression result from the effusion of blood in different situations, neither of which indeed can be ascertained after the vertebral canal has been opened, unless the sheath be rent.

Cline's operation, although his patient died, attracted great attention, and for a time its propriety was vigorously discussed. An earnest argument, often degenerating into bitter and virulent personality, was kept up for many years; Sir Astley Cooper, Benj. Bell, Tyrrell, South and others endorsing and upholding the operation, while Sir Charles Bell, John Bell, Sir Benj. Brodie, and others violently opposed it. The following quotations give an idea of the tone of a portion of the papers which were published about that period. Brodie wrote of the operation that "even under the most auspicious circumstances it must be doubtful whether it may not be productive of harm rather than of good to the patient;" while Sir Astley Cooper concludes his remarks on the subject as follows: "Though I may not live long enough to see the operation frequently performed, I have no doubt that it will occasionally be performed with success. There is no reason why it should not; and he who says that it ought not to be attempted is a blockhead." After a time, however, the controversy languished, though here and there a solitary operation, almost invariably entirely unsuccessful, was recorded.

In the *British and Foreign Medical Review* for 1838 in a critique of Sir Charles Bell's "Institutes of Surgery" the reviewer quotes a successful case, in which the operation was performed by a Welsh surgeon by the name of Edwards, resection having been made in the lumbar region. The case, however, is very imperfectly reported. The cases of Tyrrell, Barton, Wickham, Smith, Rogers and others were all unfavorable and Malgaigne, after having reviewed their results, joined the ranks of the opponents, deciding that the fatality of the

recorded cases should be sufficient to deter surgeons from so grave an operation. He believed that if the ordinary methods were not sufficient in case of fracture with displacement that we might try to act on the posterior fragment with forceps or tenacula to draw it backward, but that "the extraction or trephining of the arch presents itself as so desperate a resource" that he would not advise any one to adopt it.

In 1861, Dr. Hutchison, of Brooklyn, published (*American Medical Times*) the history of an operation for fracture, which resulted in death, and reviewed the histories of the recorded cases up to that time. He did not arrive at any general conclusion as to the propriety of surgical interference.

In 1865 considerable attention was again drawn to the operation by Dr. Robert McDonnell, who reported the case of Dr. Samuel Gordon, in which trephining of the 12th dorsal vertebra had been followed by the healing of a bed-sore, the disappearance of a virulent cystitis and the return of power over the bladder and of sensation in the rectum, the patient being still alive but unable to stand at the end of five months.

Dr. McDonnell also reported a fatal case of his own and reviewed 26 cases of trephining, in 7 of which life was preserved for some time. He called attention to cases of temporary paralysis from pressure by pus, in which the cord had entirely recovered, and to similar ones of paralysis from wounds of the spine, followed by recovery on the withdrawal of the foreign body which was causing the compression.

He concluded that instances of fractures of portions of the vertebræ, unaccompanied by fracture or displacement of the body, are not very infrequent, being 10% of the recorded cases which he was able to discover, the majority of them occupying the cervical or upper dorsal region.

He suggested that the loss of reflex movement in such patients might be due to a venous congestion of the cord below the seat of injury, not to structural change, and that such loss is therefore an additional indication for operation.

He thought that evidences of myelitis or meningitis, the girdle symptom, formication, cramps, spasms, fever, etc., contraindicated operation, but believed that the softening of the cord under pressure was quite different from ordinary inflammatory softening or "white softening," and that it indicated no structural change, from which the cord could not recover.

In the discussion in the Royal Medical and Chirurgical Society (*Medical Times and Gazette*, vol. ii., Dec. 9, 1865, pp. 639, 640) which followed the reading of Dr. Gordon's paper, Mr. Alexander Shaw called attention to the fact that in this successful case the operation was not performed till the second month after the accident, during which time the vertebral column must have undergone essential changes; so that, if the bones had not perfectly united, at least all the adjacent parts must have become consolidated by the processes of repair.

"And" he added "observations show that when patients have passed through the first stages of the accident, and have lived long enough for the injured parts to acquire some solidity and firmness, their chances of surviving, although with paraplegia remaining, are greatly increased; the probable reason being that, as they can be moved more freely in bed, and their positions more frequently changed, the bed-sores are more likely to be cured."

In 1866 Mr. Jonathan Hutchinson (*Clinical Lectures and Reports of the London Hospital*, vol. iii., p. 327) considered at length the conditions usually met with in spinal fractures and luxations, with the object of furnishing conclusive arguments in support of the usual practice at the London Hospital of abstaining from operative interference in such cases.

He asserted that a good many cases recover, if put under favorable circumstances and let alone, and that of those which end in death, very rarely indeed, could it be said after post-mortem examination, that an operation could by the barest possibility have done any good. In the great majority, then, since it could have done no good, its effect would have been to increase the patient's sufferings, and aggravate his danger.

With regard to the lesions usually met with in the post-mortem room, he made the following assertions, based on the examination of about twenty cases: First. Permanent compression of the cord, or of any part of it, is a very rare event. From my experience I should not think that permanent displacement to any material degree is met with once in ten cases. Second. As might be expected from the fact that almost all the more serious injuries to the spinal column are due to indirect violence (bends) the fractures of the laminae are of little conse-

quence and never cause compression of the cord. In almost all our cases the laminae, spinous processes, etc., are more or less fractured, but I have never yet seen a case in which any of the fragments were in contact with the cord. Third. Having thus denied that the cord is permanently compressed, either by the bodies or the laminae, I now extend my statement to extravasations of blood. I have never myself seen any effusion to the extent of possible compression, and in the majority of cases there is little or none. The injury is a crush, and is not one at all likely to cause much bleeding. There are no large arteries to be injured. Fourth. Instances of great displacement of one vertebra do sometimes occur. They are exceptional, however, and very rarely of a kind which we could rectify by force or by operation. Fifth. The cases in which, during life, there is evidence of considerable displacement are not by any means always the most serious ones. The irregularity, perceived externally, concerns rather the spinous and transverse processes than the bodies, and it is very possible that they may have been fractured without any crush of the cord; and, on the other hand, that the bodies may have been displaced for a moment, allowing complete crushing of the cord, and yet no permanent irregularity may have resulted. In justification of the strong opinion which I have already expressed against operations with the intention to elevate depressed portions of bone, I must say a few words more. *My chief reason is that by doing so you convert a simple into a compound fracture, and add the risks of pyæmia, together with those of spinal meningitis.* Then, I urge that depressions of bone very rarely exist, perhaps not one in twenty cases, and that it is utterly impossible to select the case.

INJURIES OF THE SPINE.

In 1867 Dr. John Ashhurst reviewed the subject up to that date, publishing a table of 26 cases, many of which were included in Dr. Hutchison's and Dr. McDonnell's collections, reviewed their clinical history, said that there was not in fact one well authenticated instance of recovery from spinal resection and concluded that in no case did resection or trephining offer a reasonable prospect of improving the patient's condition; but that on the contrary there was reason to fear that they increased the chances of fatal termination.

In 1859 Mr. Thomas Nunnely, in an Address on Surgery before the British Medical Association, again brought the sub-

ject to the attention of the profession. He said that while the great majority of surgeons had had an unfavorable opinion of the operation of resection of the spine after fracture or dislocation with symptoms of compression, and while for many years it seemed to have been almost forgotten, yet he could not but think that this position had resulted more from submission to habit or to traditional authority than from a due consideration of the subject. He reported four cases of his own with one recovery, reviewed the tables of McDonnell, and concluded that out of 33 cases of fractures in various parts of the spine, life had been permanently saved in three, and considerably prolonged in three others, and that in still others general improvement had resulted. He called attention to the fact that all the successful cases were most unfavorable at the time of the operation and should, therefore, not be compared with large collections of injuries to the spine, of all grades of severity. His general conclusion, therefore, was distinctly favorable to the operation, and he quoted with approval the dictum of Sir Astley Cooper who, more than once, declared that if one patient out of one hundred could be saved it would be better than could be hoped for from nature alone. During the same year, however (1869), Mr. LeGros Clark, in a lecture on Diseases of the Spinal Cord (*The British Medical Journal*, vol. ii, July 17, 1869, pp. 49-52), took equally strong ground against the operation. His argument may be summarized as follows:

The end proposed in an operation of this kind is to remove displaced bone which is supposed to press upon or irritate the cord. But such a proceeding is most likely to prove abortive from the inaccessibility of the displaced bone, fractures of the arches alone being very rare except from direct violence. But the direct violence which would suffice to fracture the arch and drive the spinous process into the cord, the body of the vertebra remaining unbroken, must almost inevitably prove hopelessly destructive to the nerve tissue. Again: If the surgeon operate early he does so before it is known whether the injury is permanent, a fact which can only be developed by time; if he wait he diminishes his chances of success. If he does operate, he converts a simple fracture into a compound fracture, and a communication is established with a canal having the most delicate and susceptible rela-

tions, and which must be liable to the intrusion of the products of inflammation during such period as the patient may survive the effort to repair the lesion. If the cord has been crushed, and the operation has been consequently useless, probably life may be, thereby, only curtailed; but if (as must be presupposed for the operation to have a chance of success) the cord be not crushed, it appears that the best chance for the patient's recovery is thereby extinguished. The operation has been advocated on the *erroneous hypothesis that the spinal cord can be compressed, without serious disintegration of its texture. I believe this is scarcely ever the case*, unless such pressure result from extravasation of blood, a condition which, if it could be ascertained, would not be regarded as indicating operation.

The only supposable form of spinal surgery which, in my opinion, might be benefited by operation, is a fracture of the vertebral arch alone, with limited depression, or the recent intrusion of a spiculum of bone within the theca, whereby the cord is pricked and irritated. But where are these cases to be met with, and how are they to be recognized? I fear we must abandon this operation. It can scarcely be alleged by its advocates that, if unproductive of good, it is harmless. To weaken still further the remaining connections of a broken spine, to convert a simple into a compound fracture, to expose the sheath of the cord and possibly the cord itself, and to entail the risks attending the period of repair, cannot be regarded as circumstances of indifference.

At present, with every disposition to regard this subject impartially, and to give their due weight to the arguments and facts which have been advanced in its favor, I cannot regard trephining the spine as brought within the pale of the justifiable operations in surgery.

In 1870, M. Brown-Sequard, from the point of view of a neurologist, as well as an experimental physiologist, upheld very strongly the theory that death after fracture of the spine is usually due to the effect of continued irritation of the cord by pieces of broken bone and not to the results of a partial or complete section of this nervous centre. (*Physiology and Pathology of the Nervous Centres.*) He quoted the clinical history of many cases to prove that section, or even crushing of the spinal cord, had not proved fatal, and emphasized the fact that in animals death is rarely caused by complete section of the cord in the dorsal region, while they die as quickly and as often as men

after fracture of the spine if the broken pieces are not removed. He further called attention to the removal of the body of the third cervical vertebra by an Italian surgeon in a case of sypnilitic caries, to another analogous case also operated upon by an Italian surgeon, and to two cases of cyst in the spinal canal with erosion and expulsion of portions of the vertebræ, all of which recovered.

He believed that as the result of his investigations the following conclusions were justifiable: (1) That the laying bare of the spinal cord is not a dangerous operation; (2) that death after a fracture of the spine is usually due to the effects of pressure, or of excitation of the spinal cord, and is not the result of a partial or a complete section of this organ; (3) that reunion may take place after a wound of the spinal cord, so that its lost functions may return; (4) that the removal of some parts of the vertebræ may be followed by a production of new bone; (5) that the cases of fracture of the spine in which the trephine has been applied show the usefulness of this operation.

In spite of this pronunciamiento, another long interval ensued with very few reported cases which I have been able to discover, of resection of the spine in case of injury. Two cases in 1870, operated on by Cheever, of Boston, both resulted fatally, as did one operated on by E. R. Willard in 1871, and one by Lucke in 1880. Stemen, of Indiana, in 1883, reported three cases, one relieved, one not benefited, one fatal in eight days.

In 1884 Dr. John A. Lidell, in the article on Injuries of the Back, in vol. iv of the *International Encyclopædia of Surgery*, quoted Ashhurst's statistics, recorded the statement of Prof. Eve, of Nashville, to the effect that resection of the dorsal vertebra is "one of the most difficult in surgery, if not impracticable," and concluded that the operation of resection or trephining the vertebræ is unjustifiable, because it does not offer a reasonable prospect of improving the patient's condition in any case, while, on the other hand, there is always reason to fear that it may increase the chances of a fatal termination.

In September, 1884, Dr. Halsted, of New York, operated at the Roosevelt Hospital on a patient, who three days previously

had suffered a fracture of the spine of the twelfth dorsal vertebra with rotation and forward luxation of the body of the same vertebra and fracture of the right transverse process of the first lumbar. The displacement was reduced with the help of Langenbeck's hook, but the patient died seventeen hours later. (*Medical News*, January 3, 1885).

In November, 1884, Dr. Pinkerton, acting as house-surgeon for Dr. E. L. Keyes, removed the spinous process and lamina of the twelfth dorsal vertebra, which had been fractured four days previously. The patient died five days later. (*Ibid*).

In February, 1885, Mr. William Macewen (*British Medical Journal*, August, 11, 1888) operated in the case of a man who, six or eight weeks previously, had had a severe injury to the spine at the level of the lower dorsal vertebræ. He had absolute motor paralysis, incontinence, hyperæsthesia followed by anæsthesia, rapid muscular atrophy, cystitis, bed sores, pyrexia, etc. Resection was performed; the arch of the 12th dorsal was found fractured and depressed; a connective tissue tumor between it and the theca was removed, as well as the laminæ involved. The patient made a good recovery and a year later could walk about with ease and without support.

In 1886, Dr. Robert T. Morris reported (*ANNALS OF SURGERY*, June, 1886) the case of a patient who, as the result of a fall upon the head, had complete paraplegia with loss of sensation and of motion at nearly all points below the neck. Two years and three months after the accident the laminæ and spinous process of the 7th cervical vertebra and the spinous process of the 6th cervical vertebra were removed. The patient lived ten months but was not materially improved. At the autopsy very extensive disease of the cord itself in the neighborhood of the injury was found. The membranes were thick and firmly adherent to each other and to the vertebræ.

In 1886 Dr. Carl Lauenstein, of Hamburg, reported (*Centralblatt f. Chirurgie*, No. 51, 1886; *London Med. Record*, March 15, 1887) the case of a patient who, five weeks before coming under observation, had had a fall of forty feet. This was fol-

lowed by paraplegia, incontinence of urine and fæces, trophic changes, etc. There was a projection in the dorso-lumbar region, most prominent over the spine of the last dorsal. The use of a plaster jacket had failed to give relief. The arches of the last dorsal and first lumbar vertebræ were removed by means of a chisel.

Six months later the patient was able to walk, the incontinence had disappeared, and he was reported as quite recovered.

With the view of deciding the question whether such improvement as had resulted in this case could possibly be attained without the performance of a surgical operation, Dr. Lauenstein has looked over published reports of similar cases, and studied especially the statements referring to paralysis of the bladder. The relief of this condition, he states, is a point of much importance, for, with the exception of bed-sore, which usually occurs in such cases, cystitis is, undoubtedly, the most formidable of all the secondary symptoms. Of fifty-three cases of so-called cure of fracture of the spine, collected by Gurlt in his work on fractures, there are fifteen instances of spontaneous restoration of the functions of the bladder and rectum. The shortest interval between the date of the accident and that of complete restoration of the functions of these organs was a few hours, and the longest interval eight weeks.

In not one of six cases of fracture of the spine with paralysis of the bladder, treated by Lauenstein during the last six years, was any spontaneous improvement observed in this latter condition after long intervals. It is concluded from these returns that when, in cases of compression of the cord from fracture of the spine, the functions of the bladder and rectum are restored, this restoration usually takes place after a brief interval, and that if no improvement has taken place in the course of ten weeks, any subsequent spontaneous change for the better in the condition of the bladder can hardly be anticipated. In the case reported by Dr. Lauenstein the bladder symptoms just before the operation were increasing in severity. Since the introduction of the antiseptic method into practical surgery two other instances in addition to Macewen's and Morris' cases had been reported up to this date (1887) of operative interference for the relief of paralysis from injury to the spine.

The first of these, reported by Maydl, from the hospital practice of

Albert. had been diagnosed as a case of fracture of the spine in the dorsal region, but was found to be one of luxation and crushing of the cord. The patient recovered from the operation. In the second case, reported by Lucke, the operation was performed two days after an injury to the spine, which was found to consist in fracture with crushing of the corresponding part of the cord. This patient also recovered from the operation, but died nine months later from marasmus, and without any but very slight improvement having been observed in the condition of the paralyzed limbs. In six only of thirty-one cases collected by Werner of operations performed on fractured spine in the pre-antiseptic era did the patients recover from the effects of the operation. These results, however, Dr. Lauenstein held, can not be brought forward to discredit the operation of trephining the spine, since sufficient care was not taken in their selection; and the treatment was applied in instances both of recent and of old injury, and even of complete crushing of the cord.

Dr. Lauenstein would not operate in a case of recent injury to the spine, as it is well known that occasionally in such instances the symptoms of paralysis disappear spontaneously in the course of a few weeks.

In the *Edinburgh Medical Journal* for March, 1889, Mr. John Duncan reports three cases of fracture of the spine with paralysis which were operated upon by removal of the laminae of the broken vertebrae. One case died on the following day; the others recovered from the operation but were unimproved.

Horsley, in a foot-note to his paper on the case of spinal tumor, says he has operated on a case of fracture and that the wound healed rapidly, but gives no other details. In the paper itself he also mentions a most interesting case of operation for the paralysis following fracture, in which the wound healed rapidly, as did a large bed sore. There was but little general improvement.

It was found in this case that the spinous process of the 11th dorsal vertebra was jammed forward between the 10th and 12th, and also that there was backward compression of the cord against the lamina of the 10th vertebra. These were removed. Mr. Horsley makes the following remarks apropos of these cases, and with reference to the dictum that when there is evidence that the cord has been severely jammed or compressed at the time of accident, an operation is contra-indicated.

"In this case no doubt the spinal cord was momentarily jammed at the time of the accident so severely as to practically, *i. e.*, functionally, divide it. Though laminæ were found compressing it at the time of the operation, nevertheless they did not do it so severely as to thereby alone cause the excessive degree of the symptoms, therefore it would seem that the cord, as suggested, must have been compressed at the time of the accident. Now, this is just a case in which, if any attention had been paid to the ruling before quoted, the patient's life would have been lost, and indeed it must be obvious that, considering the necessarily small amount of information on this subject, it should be our duty to operate in every case, since we may possibly do some good, and certainly, if proper antiseptic precautions be taken, we can, to use Mr. Erichsen's words, do no harm.

This question of the damage to the spinal cord not appearing to discount the possible benefit of surgical interference so much as has been hitherto expected, gains additional illustration from the case which forms the subject of this paper, since nothing could well have appeared more hopeless than the indentation of the spinal cord produced by the tumor. This indentation appeared to divide the lateral column completely, and yet, owing doubtless to the gradual character of the compression, the restoration of motor and sensory function has been complete. I would repeat, therefore, that, so far from its being unjustifiable to operate on the spine owing to the possibility of the cord being hopelessly damaged, it seems to me to be criminal not to operate."

Mr. Ernest Hart reports (*The British Medical Journal*, March, 23, 1889,) a case of Péan's in which paraplegia, retention of urine, etc., followed a severe contused wound of the mid-dorsal region caused by the bite of a horse. The spinous processes of the 7th and 8th dorsal vertebræ were not to be felt. Péan removed by operation the fragments of these processes, and of the corresponding laminæ which had pierced the membrane and entered the substance of the cord itself. He resected the irregular ragged fragments of the transverse processes. Mr. Hart reports that the operation was completed without complication, and that "the patient is now restored to almost his ordinary condition."

Mr. Herbert Allingham reports (*British Medical Journal*, April 13, 1889, p. 838) two cases of fracture of the spine treat-

ed by trephining. In one there was fracture with depression of the lamina of the sixth dorsal vertebra; the spines and laminae of the fifth, sixth and seventh were removed. The wound healed in ten days. The symptoms of ascending changes were checked. Improvement to some extent occurred.

In the second case the spines and laminae of the third, fourth, fifth and sixth dorsal vertebrae were removed; the wound healed in a fortnight. No mention of the subsequent course of the case is made except the fact that the woman died seven weeks later, and that the cord was found almost divided.

I believe I have now given a fairly complete view of the history of this operation in cases of fracture and luxation and with sufficient detail to permit of a reasonable estimate of its present position before the profession.

The arguments employed against operation in these cases of pressure upon the cord from fracture or displacement may be summarized as follows: It was said that there was great difficulty of diagnosis between the cases in which the operation would probably prove useful, and those in which it would probably afford relief on account of the limited extent of the injury. This is undoubtedly true, but a precisely similar argument will apply to many other serious and frequently employed operations, and all the most recent additions to our knowledge of the subject, whether derived from clinical experiments or from experimental and pathological investigation, lead us to assign to the cord a much greater power of repairing damage than was formerly thought to be conceivable.

It was said that the position of a fractured bone often rendered it impossible to reach it; and that the pressure was commonly from the bodies of the vertebra which could not be removed. A careful review of reported autopsies shows that the proportion of cases in which the pressure is from the laminae is much greater than has been supposed, and that this assertion is as true now as when originally made by Mr. Nunely 20 years ago.

It is very easy to demonstrate that the sweeping statements which have been quoted, as to the rarity of direct compression by the arches and spinous processes, are not justified by

the facts. I append a number of references to cases of this character selected almost at random from medical literature, while seeking information as to other points. They might be multiplied indefinitely.¹ They demonstrate that, in addition to the relief which we may fairly expect to give by removal of the lamina even in cases of compression by posterior displacement of the bodies, we may also expect in a very considerable proportion to remove completely and permanently the actual compressing and irritating factor, thus giving the cord an opportunity for reparative action if it has not been hopelessly crushed or disorganized—an opportunity which could not conceivably occur if the patient were left to the unaided processes of nature.

¹Perhaps the following case recorded by a distinguished neurologist will serve as well as any, as an example of a group of cases which a very little research shows to be by no means infrequent.

Dr. Charles K. Mills has reported (*The Polyclinic*, vol. 1, No. 9, 1884) the case of a man who had been crushed by the roof of a building falling upon him; he had motor and sensory paralysis, never recovered, and died of exhaustion five years later.

A post-mortem examination was made thirty hours after death by Dr. Flick. The vertebra¹ column had been fractured at the position of the 12th dorsal and 1st lumbar vertebræ. The posterior portion of the upper of these bones had been broken and driven inward, and its fragments were overridden by a portion of the lower injured vertebra. The dura mater was adherent to the bone at the seat of the fracture. In the external layer of the dura, just at the lower end of the spinal cord, was a bony mass, one-half inch long by one fourth inch wide. The membrane, for a short distance above this point, and down the cauda equina, was much thickened and covered with a dirty exudation. The cord at this point was red and very soft. The spinal canal contained a large effusion.

Cases more or less similar, but agreeing as to the occurrence of fracture of accessible portions of the vertebræ, have been reported by Astley Cooper, *Fractures and Dislocations*, Stephen Smith, *N. Y. Journal of Medicine*, vol. vi, 1859; Curling, two cases, *London Hospital Reports*, vol. 1; Van Syck, *N. Y. Journal of Medicine*, vol. iii, 1857; Eberman, *Am. Journ. of Med. Sci.*, October, 1879; Arnott, *Lancet*, 1851; Bransby Cooper, *Lancet*, 1828; Williamson, *Dublin Quarterly Journal*, vol. 27; Boyer, *Surgical Works*, vol. 2; C. S. May, *Am. Journ. of the Med. Sci.* Oct. 1876; Erichsen, *Science and Art of Surgery*; Malgaigne, *Treatise on Fractures*, Packard's Trans., *N. Y. Jour. of Med. and Collat. Sci.*, Sept. 1849, p. 268; Hamilton, *Treatise on Fractures and Dislocations*, *Guy's Hospital Reports*, vol. ii, p. 480; F. H. Hamilton, Jr., *American Medical Times*, N. S., vol. 8; Berkely Hill, *Trans. Royal Med. and Chirurg. Soc.*, Jan. 22, 1867; Abernethy, J. Comstock, *Bost. Med. Jour.*, 1848; William Pepper, *Trans. Patholog. Soc. of Phila.*, 1867; T. B. Ladd, *Boston Medical Journal*, 1852; A. P. Clarke, *Journal of the Am. Med. Ass'n.*, October, 1884; S. D. Townsend, *Am. Jour. Medical Sciences*, O. S., vol. 22; J. Solis Cohen *Trans. Patholog. Soc. of Phila.*, 1878.

Of the 53 cases of resection for fracture and luxation which have thus far been recorded I find that in no less than 21 was there a fracture of the lamina or processes, a percentage of 6.2 which, while it is undoubtedly in excess of the actual frequency of this form of fracture, should yet be studied in the light of the statement made by the opponents of the operation, viz., that it is impossible to tell with accuracy the extent of the damage and the particular parts involved. If this impossibility really exists it is all the more important that we should not lose sight of the fact that the injury *may* be one quite relievable by operation.

Even when the pressure is anterior, having been caused by displacement or fracture of the vertebral body, removal of the posterior arches increases the calibre of the canal and increases also the chance of avoiding irreparable damage to the cord by compression. That it is unsafe to say in any given case that the cord is *hopelessly* damaged would seem to be fairly well established by the results of such cases as Horsley's, Macewen's and Lauenstein's, so that operation should scarcely be refused on that score alone.¹ A still further argument was that the ex-

¹In his article in Holmes' Surgery (vol. iv., p. 130), Alexander Shaw says: "Changes of the most extraordinary magnitude may be effected in the brain and cord by encroachments of various kinds, without the sacrifice of their functions, on condition that the intrusion is made slowly and gradually." This opinion has been reiterated even by surgeons who like Mr. Shaw, earnestly oppose resection, and is used as an argument for trusting the patient to the *vis medicatrix natureæ*. Prof. Eve has brought together (*Am. Jour. of the Med. Sciences*, July, 1868) eleven cases of supposed division of the spinal cord, in which life was variously prolonged, and in one of which recovery was complete. In the lower animals the results of vivisection experiments have been somewhat contradictory, but on the whole sustain the view that the cord like other nerve trunks possesses extraordinary regenerative power. In some animals true nervous matter is reproduced after part of the cord has been destroyed; at least, this is so in tritons and lizards (Müller). As is well known in these animals, when the tail is removed it is reproduced, and Müller found that a part of the spinal cord corresponding to the new part of the tail is reproduced. Morphologically the elements were the same, but the spinal nerves were not reproduced, while physiologically, the new nerve substance was not functionally active. It corresponds, as it were, to a lower stage of development.

According to Masins and Vulain, an excised portion of the spinal cord of a frog is reproduced after six months; while Brown-Sequard maintains that reunion of the divided surfaces of the cord takes place in pigeons after six to fifteen months. A

posure of the cord and membranes to the air would inevitably set up a destructive inflammation, an argument which in these days of antiseptic surgery need not further be considered. The general conclusions that the operation was too difficult, was too prolonged, that there was danger of fatal hæmorrhage, etc., were, as experience has shown, largely theoretical and although the operation is certainly not an easy one, and although one operator did lose his patient on the table from hæmorrhage while attempting to perform it, it is still one which may be confidently undertaken by any experienced surgeon.

In reviewing the statistics of these operative cases it seems to me quite proper that those belonging to the preantiseptic period should be omitted, or should be regarded in a category by themselves. I do not mean that all, or even that a majority of the fatal cases, were due to septic disease. In many of them the time was too short, in others death resulted from intercurrent disease of other organs, but a sufficiently large proportion were so distinctly septic as to invalidate any sweeping conclusions based upon these results, sepsis after this operation being as absolutely avoidable as after any in surgery. This would leave then, in a class by themselves, the thirteen operations for fracture of Macewen, Morris, Horsley, Lauenstein, Lücke, Albert, Duncan, Péan, and Allingham with three complete recoveries, two recoveries from the operation with benefit, seven recoveries unimproved, and one death.

The chief strength of the opponents of operation lies in the argument that the operation *per se* is of great danger or in itself materially diminishes the patient's chances. If, as I believe to be the case, it can be fairly claimed that rapid reunion of all the soft structures down to the dura mater itself can be confidently expected; if it can be shown, as it has been, that the most extensive

partial reunion is asserted to occur in dogs by Dentan, Nannyn and Eichhorst, although Chieferdecker obtained only negative results, the divided ends being united only by connective tissue (Schwalbe).

Eichhorst and Nannyn found that in young dogs, whose spinal cord was divided, not excised, between the dorsal and lumbar regions, there was an anatomical and physiological regeneration to such an extent that voluntary movements could be executed. Vanlain in the case of frogs, and Masins in dogs, found motility restored first, and sensation afterwards.

resections of the laminae do not greatly or permanently weaken the spine; if under antiseptic methods the risks of consecutive inflammation of cord or membranes are practically nil; if hæmorrhage is not to be feared, and loss of cerebro-spinal fluid is unimportant;¹ if it happens not so very infrequently that the cord is directly compressed by fragments of the laminae themselves, or if not, that by removal of the arches relief from the anterior pressure is afforded; if these are facts, or even reasonably strong probabilities, it is evident the operation is one which should no longer be rejected on the sole remaining ground that we cannot be certain in any given case as to the exact amount of damage which has been done to the tissues of the cord. The argument that if such damage were irreparable, operative interference would be useless, while if the cord retained the power of recovering itself the operation only added another complication, has lost nearly all its force. It would seem rather to be the duty of the surgeon after a reasonable and not very protracted delay to endeavor to relieve any possible pressure, to remove any fragments or spiculæ of bone, to drain thoroughly the canal or even the subdural space if there were any oozing and to do so with the consciousness that if he meet with none of these conditions, he is at any rate not performing a necessarily fatal operation.¹

2. As time went on the application of operative methods to the diseased conditions of the spinal cord and canal, other than those produced by injury or accident was naturally thought of.

In the second group of cases which includes those of spinal

¹Dr. Herbert Burrell in a valuable paper read before the Massachusetts Medical Society, June, 1887, has recorded the results of immediate rectifications of the deformity and fixation of the spine by means of a plaster jacket. He details sixteen cases, in which three died, three derived no benefit from the method, and ten were greatly benefitted. He arrives at the following conclusions:

1. That in the immediate correction of the deformity and fixation with plaster of Paris jacket or other means, we have a rational method of treating a large number of cases of fractures of the spine.

2. That considering the hopelessness of results in fracture of the spine when treated expectantly, almost any risk is justifiable.

3. That the immediate correction of the deformity is imperative, if softening of the cord can and does occur from pressure at the end of forty-eight hours.

paralysis due to pressure by pus or by carious vertebræ, we have some encouragement to operation held, out in the clinical facts:¹ (1). That there are very many examples of the relief of paralysis in spinal caries, after the pointing of a psoas or iliac abscess, or after the evacuation of pus by the side of the spine. It is scarcely worth while to give special instances of the truth of this statement. It is familiar to all who have seen many cases of Pott's disease. Of course in such instances the evacuation of the abscess when it is accessible, or the performance of Treves's operation for the removal of the carious portion of the vertebræ is clearly indicated. (2) By the fact that the disease of the dura matër in Pott's disease is limited to the site of the diseased vertebræ. The change from an inflammatory to a normal area is an abrupt one. Dr. George R. Elliott in a valuable paper on the Pressure Paralysis of Pott's Disease (*N. Y. Medical Journal*, June 2, 1888) has fully developed this point, long ago advanced by others, in an argument to sustain the theory that this paralysis is due chiefly, almost entirely, to pressure and not usually to grave changes in the cord itself. Some of his conclusions, sustained by au-

4. That the suspension of the patient is only a means of rectifying the deformity; that certain fracture could be simply pressed into position while the patient lies prone or supine.

The objections to the treatment are:

1. That the expectant plan of treatment gives a small percentage of recoveries.
2. That there are, especially in the cervical region serious risks attending the suspension of a patient and the rectification of the deformity with a fractured spine—in the way of shock, collapse and death.
3. That in attempting to relieve pressure on the cord, by rectifying the deformity, we might either sever the spinal cord or make pressure upon it. This is a matter of chance.

My own belief regarding the status which the procedure should occupy in surgery is, that it will occasionally be a life-saving measure; that it should be applied under anæsthesia in all cases of fracture of the spine, which are not conclusively known to be irremediable; and that apart from the chance of recovery offered to the patient by this means, it will almost invariably make the patient more comfortable, in that he can be handled more easily.

¹Lidell. Internat. Encyc. of Surgery, vol. iv., p. 786.

toppies in twenty-one cases, have a direct bearing upon the question and may be found subjoined.¹

That these statements, at least in so far as they attributed the paralysis of Pott's disease to an external pachymeningitis rather than to direct pressure from the bones themselves are not new ones, a few quotations will demonstrate. Hippocrates, writing of spinal cases, said :

The palsy of the legs and arms, the wasting of the body, and the retention of urine happen chiefly in those cases where there is no spinal deformity, nor any projecting bone forward or backward; and paralytic affections take place the least frequently in cases of gibbous or angular projections

Mr. Percival Pott, writing in 1720 on "The Useless State of the Lower Limbs in Consequence of a Curvature of the Spine," says :

Since I had been particularly attentive to the disorder, I thought that I had observed that neither the extent nor degree of the curve had in general produced any material difference in the symptoms, but that the smallest was, when perfectly formed, attended with the same consequences as the largest, and that the useless state of the limbs is by no means a consequence of the altered figure of the spine, or of the

¹It seems to him demonstrated: That we have present a simple mechanical pressure in the form of abscess products, thickened dura or bone; that the inflammatory process is invariably a limited one, the inflammation of the dura mater being restricted exactly to the site of the diseased vertebræ, exhibiting no tendency to extend in the membrane—nature's medullary protection; that the medullary surface of the dura mater is almost invariably normal. It follows, then, that the pressure lesion is simply mechanical, possessing no tendency to involve the spinal cord through any inherent specific characters of the carious process—a bland mechanical lesion—and the damage it inflicts commensurate with the pressure exerted.

Experimental physiology gives no evidence of an inflammatory lesion following experimental compression of the cord. A careful examination of the pathological findings of reported cases reveals to us, in the light of recent pathological knowledge, but few instances where we have reason to believe the original lesion to have been inflammatory. These were cases where the process was virulent, leading to a perforation of the dura mater, thus allowing the purulent products to come in direct contact with the cord, giving rise to a lepto-meningitis.

Finally, then, Dr. Elliot concludes, our researches have led us to the belief that the original lesion is, as a rule, non-inflammatory, an opinion supported by pathology and experimental physiology, and corroborated by clinical manifestations.

disposition of the bones with regard to each other, but merely of the caries.

Michaud, in 1871, completely elucidated the mechanism of this form of paralysis. (*Sur la Meningite et la Myelite dans le mal vertebra.*)

Dr. Thomas Buzzard, reporting a case of Pott's paraplegia (*The Transactions of the Clinical Society of London*, vol. 13, 1880), says :

The spinal cord was curved abruptly at an angle of 125° , but the cavity in which it lay, although encroached upon to a certain very small extent by the thickening of tissue external to the dura mater, did not appear to be sufficiently narrowed to affect the calibre of the cord. There was no pinching or obvious compression, except what was due to the bending of the cord upon itself. The soft membranes, the surface of the cord, and the internal surface of the dura mater were entirely free from traces of inflammation.

Gowers says (*Diseases of the Nervous System*, 1886, vol. 1, p. 169):

The inflammation extends to the loose cellular and adipose tissue between the bone and the dura mater, and often to the dura mater itself, the outer layer of which becomes irregularly thickened in the neighborhood of the disease. The inner surface of the dura mater is often normal when the outer surface is much changed. Inflammatory products, cheesy material, pus, etc., accumulate between the bone and the dura mater, and often in such quantity as to compress the cord. Inflammation is frequently set up in the cord, but usually only when it is compressed. The damage to the spinal cord depends on the secondary consequences of the caries, and both its occurrence and character are variable and uncertain. The mechanism of the damage is twofold—compression and inflammation. The mechanism of compression varies. The most frequent is the collection of inflammatory products outside the dura mater, and the thickening of this membrane. Less commonly the cord is compressed by the displacement of the bone, or by fragments of bone that are pushed into the canal.

On May 9, 1883, Mr. William Macewen, in a case of complete sensory and motor paraplegia, with incontinence of urine and feces, and of two years duration, the result of angular curvature of the spine, removed the laminæ of the 5th, 6th, and 7th dorsal vertebræ. Between the theca and the bone he found a fibrous neoplasm one-eighth of an inch in thickness firmly attached to about two thirds of the circumference of the membranes; this was carefully dissected off; 24 hours later improvement began, and in 6 months the patient was able to walk. In 5 years afterward he was attending school and joining in all the games including foot-ball. Mr. Macewen's cases of paraplegia in Pott's disease, included four others, two of which were successful, one of them being of the most aggravated character imaginable. The connective tissue tumor was very dense, intimately adherent to the theca, and the cord beneath was shrunk, to half its dimensions, and lay like an inanimate rod. Several laminæ were removed, but at no time during the operation were there any distensible pulsations of this part of the cord. It was thought that there was no hope of the patient, a female, recovering from her paralysis, but she did so, walked a quarter of a mile eight months later, and now does house-work and enjoys life. A third case was also successful. The two fatal cases died, one a week after the operation, the other eight months later, of general tuberculosis.

Recently Mr. Horsley has operated upon a case of complete paralysis of all four limbs from caries of the 2nd and 3rd cervical vertebræ, and reports the case as rapidly regaining power. The wound healed without the slightest complication.

In December, 1888, I operated upon a paraplegic patient with Pott's disease and angular curvature. The patient had grave visceral lesions which together with the shock of the operation caused his death. The case will be found fully reported in the last number of the *ANNALS OF SURGERY*.

Dr. Robert Abbe, of New York, has recently (*Medical Record*, February 9, 1889) reported a case which he describes as an extra-dural tumor of the spine, but, which seems to have been a case of caries of the dorsal vertebræ followed by localized suppuration with inflammatory thickening and dessi-

cation of pus, rather than a tumor causing caries by pressure. In this case the spines and laminae of the 8th, 9th, and 10th dorsal vertebræ were cut away by the rongeur and the mass of dense tissue above the spine removed. The patient made a rapid recovery, regaining the ability to walk while pushing a chair. In another case of intractable brachial neuralgia the laminae of the vertebræ from the 5th cervical to the 3rd dorsal were removed upon the right side, and the posterior roots of the 6th, 7th, and 8th cervical nerves were divided. The patient made a quick recovery.

Mr. Duncan has reported (*Edinburgh Medical Journal*, March, 1889) a case of paraplegia of nearly a year's standing and due to Pott's disease, relieved by the removal of the spines and laminae of the 4th, 5th, 5th, and 7th dorsal vertebræ.

Mr. W. Arbuthnot Lane reports (*British Medical Journal*, April 20, 1889) a case of Pott's disease with angular curvature in a child æt. $7\frac{1}{2}$ years. The curvature was about the middle of the dorsal region. For 11 months he had been paralysed. The spinous process and laminae of the fourth, fifth and sixth dorsal vertebræ were removed with bone forceps. The body of the fifth appeared abnormally near the laminae of the adjoining vertebræ, and the cord seemed to have been forcibly compressed between those bony points. The wound healed under two dressings. A month later he was able to move both legs freely, and at the time the case was reported seemed on the road to recovery.

The cases of Macewen give strong corroborative evidence in favor of the theory of extra-dural pressure rather than interstitial cord change as the cause of the paraplegia in these cases as does that of Horsley, the cord recovering there from the effects of the pressure of the tumor, which had been exerted with sufficient firmness, and for so long a period, as almost to hemisection it. Duncan's case and Horsley's other case (of Pott's paralysis) are also valuable evidence in the same direction.

We thus have another small series of secondary operations, *i. e.*, those for spinal caries performed during the era of scientific surgery, and including the ten operations of Horsley,

Macewen, White, Abbe, Duncan, and Lane, with three complete recoveries, four recoveries from the operation with benefit, and three deaths, one eight months after the operation, and from systemic disease.

The evidence seems to be fairly conclusive that the cause of the paralysis in Pott's disease is not, as a rule, a transverse myelitis or a hopeless degeneration, and is not due to the pressure of the carious or displaced vertebræ, but is in the majority of cases the result of an external pachymeningitis which results in the formation of an extra-dural connective tissue tumor.¹

This fact taken with the above clinical evidence at any rate seems sufficient to my mind to warrant the suggestion that in the future in all cases of paralysis from spinal caries, we should, after (1st) evacuating pus whenever it is accessible, and (2nd) having treated the patient by the extension process with a plaster jacket, proceed at once to a resection, if these prove unsuccessful after a fair trial.

Resection of portions of the body of a vertebra has been performed in paralytic cases on the 6th and 7th cervical vertebræ by Podres (*Russkaja Med.* No. 19. 1886) with recovery; on the dorsal vertebræ by Bœckel with excellent results

¹In an admirable paper by Weir Mitchell on The Treatment of Pott's Paralysis (*The American Journal of Medical Sciences*, May, 1889), the following conclusions are reached:

That suspension should be used early in Pott's disease; that used with care it enables us slowly to lessen the curve; that in these cases there must be in some form a replacement of the crumbled tissues; that unless there is great loss of power, the use of the spine-car or chair, etc., of John K. Mitchel, enables suspension, especially in children, to be combined with some exercise; that no case of Pott's paralysis ought to be considered desperate without its trial; that suspension has succeeded after failures of other accepted methods; that the pull probably acts more or less directly on the cord itself, *and that the gain is not explicable merely by obvious effects on the angular bony curve*; that the well-known influence of extension in Pott's palsy makes it probable that in other forms of spinal disease, not due to caries, extension in various forms may be of value, as has apparently been of late made clear; that the methods of extension to be used in these and carious cases may be very various, only provided we get active extension; that the plan and the length of time of extension must be made to conform to the needs, endurance, and sensation of the individual cases.

(*Schmidt's Jahrbücher*, *Phil. Med. Times*, Sept. 8, 1883). James Israel, (*Berliner Klin. Wochenschrift*, March 6, 1882) resected the arch and body of the last dorsal vertebra for caries and spinal abscess. The patient died of coincident tubercular disease on the 37th day, the wound having almost entirely healed. Mr. Treves has formulated the operation as applied especially to the lumbar vertebræ or to the last dorsal, and has reported a successful case of removal of a sequestrum from the body of the first lumbar vertebra. (*British. Med. Journ.* Jan. 12, 1889).

3. Passing now to the third group of cases, and taking up the surgery of the neoplasms of the cord unassociated with traumatism or caries, we may very briefly review the history. In the 50 cases of spinal tumor tabulated by Drs. Mills and Lloyd, and among 50 cases tabulated by Horsley, the two including practically all those of which we have any satisfactory knowledge from the surgical and pathological standpoints, no mention is made of operation in a single instance.

In 1882 Mr. Byron Bramwell, of Edinburgh, in his work on "Diseases of the Spinal Cord" made the following important suggestion in regard to this subject:

"The removal of extra-medullary tumors is not yet a recognized plan of treatment. This is partly owing to the uncertainty of diagnosis, and partly to the serious nature of the operation. The difficulties in diagnosis are disappearing, and thanks to antiseptic surgery, we can now conduct operations which were formerly unjustifiable. I would advise an operation in any case in which the symptoms were original, in which the diagnosis clearly indicated the presence of a tumor, in which there was no evidence of malignant disease, in which the exact position of the growth could be localized, and in which a vigorous anti-syphilitic treatment had failed to produce beneficial results."

Other neurologists, notably Mr. Gowers, expressed the same general views, but the strong prejudice existing among surgeons against the operation of resection, and the uncertainty of diagnosis on the part of the neurologist combined to prevent operative interference in such cases, patient after patient perishing without even an attempt at treatment.

In June, 1887, Mr. Victor Horsley operated upon a case, the symptoms of which had begun immediately after a severe traumatism in 1884, and were thought to indicate an intercostal neuralgia, localized beneath the lower part of the left scapula. For a long while the pain was the only marked symptom, but in February and March, 1887, there came on distinct loss of power in the legs, and by June the symptoms were those characteristic of a transverse lesion of the cord a little above the middle of the dorsal region.

Mr. Horsley operated very much after the method employed many years previously by Gordon, McDonnell, Hutchison and others, trephining the lamina of the fifth vertebra after having first cut off the fourth, fifth and sixth dorsal spines. After the removal of the trephine button the rest of the laminæ of the fourth, fifth and sixth dorsal vertebrae were then removed with the bone forceps and knife. The dura mater was opened but nothing abnormal was discovered. The third and seventh laminæ were then removed, and finally the lamina of the second dorsal vertebra, disclosing an oval or almond shaped tumor which subsequently proved to be a fibro-myxoma. This was easily removed when the lateral column on that side was found to be so notched by pressure that the bottom of the groove nearly reached to the middle line of the cord. The patient made an excellent and fairly rapid recovery, and one year later was able to do a day's work of 16 hours, including much standing and walking about.

In July, 1888, Dr. John B. Deaver operated upon a patient of Dr. Hendrie Lloyd's who had a swelling involving the left lateral region of the cervical spine which was thought to be a tumor extending outward from the spinal canal. She had paresis of the left arm, paralysis of the left leg, exaggerated reflexes, etc. There were no paræsthesiæ and no anæsthesia.

At the operation the laminæ of the third and fourth cervical vertebrae were cut through but nothing abnormal in the cord or membranes was found. The cord was explored with a needle. During the latter part of the operation the respiration altered and continued to be gasping and irregular at intervals until her death, three days later. At the autopsy there was found an old extravasation of blood with advanced degeneration a short distance below the decussation of the pyramidal

tracts. Death was thought to be due to phrenic inhibition. the result of the exploratory procedure.

In October, 1888, I operated on a case of paraplegia thought to be due to focal spinal lesion, possibly to a tumor, in a patient of Dr. F. X. Dercum. The case will be found reported in the June number of the *ANNALS OF SURGERY*. Although no tumor was found, the removal of peri-dural connective tissue which had undergone some thickening and the separation of sub-dural adhesions were followed by very marked improvement in sensation and mobility, which improvement is still continuing.

We may now consider the possible indications for operation in this third group of cases, or those in which, fractures and dislocations having been excluded, there is reasonable ground for suspecting the existence of a removable neoplasm: Naturally, this group will, more than any other, try the diagnostic powers of both surgeon and neurologist, and no broad view of the subject can be taken without a brief enumeration of the various sources of error.

In approaching any case of paraplegia for the purpose of diagnosis it will usually be easy to exclude the first group of cases or those in which the paralysis depends upon fracture or dislocation. In such cases the history of traumatism, the rapid onset of the symptoms, the deformity which usually exists, or at any rate the distinctly localized swelling and tenderness will almost invariably lead at once to a correct diagnosis. The question which will remain in doubt will usually be that of the extent of damage done to the cord and the possibility of its taking on reparative action. As to this, the safest rule with which I am familiar is that which has been formulated by Lauenstein and already alluded to, namely, that if after the lapse of six or ten weeks there is incontinence of urine with cystitis or incontinence of feces, and especially if there is also the development and spreading of bed-sores, but little is to be hoped for from the unaided efforts of nature. If, however these symptoms are absent, and if there be the least improvement in either sensation or motion, it may be justifiable for the

surgeon to delay operative interference still longer, though I am far from being certain as to this point.

The second group of cases may also as a rule easily be recognized by the history of caries and the existence of deformity. In this group the presence or absence of an abscess must, if possible, be carefully determined, as in some instances, pressure from pus alone has produced the characteristic paralysis, which was therefore unrelieved by the removal of portions of bone, while in others such purulent collections have existed as serious complications, only to be discovered at the autopsy. Arguments have already been advanced to show that the paralysis of Pott's disease is, as a rule, a pressure paralysis, distinctly localized, and not attended with such degenerative change in the structure of the cord itself as necessarily renders the case hopeless. While there are exceptions to this rule, as will be seen in one of the cases reported by Dr. Dercum and myself, it may, nevertheless, I believe, be taken as a safe working hypothesis, which should encourage the surgeon to attempt to relieve pressure even after the long continuance of a complete paraplegia. The temperature of the patient which, during the existence of suppuration, or especially while acute changes are going on in the vertebral bodies, will probably be moderately elevated, the presence of coexistent tubercular disease in other organs, the history of the same disease in parents or near relatives, together with the well-known and easily recognized symptoms of spinal caries will make an error of diagnosis in this class of cases well nigh impossible.

It, however, we have to deal with a case of paraplegia which is distinctly not one of either of the foregoing varieties, the diagnosis will at once become much more difficult. A consideration of this subject will lead me upon ground properly belonging to the neurologist, but I may perhaps be pardoned if I give a brief outline of the general diagnostic points which it will be necessary to bear in mind before deciding upon or rejecting operative interference. In the first place it will be requisite to determine whether the symptoms are due to pressure upon the cord or to inflammatory or other changes involving primarily the structure of the cord itself. If, in a

case of paraplegia, we have the history of a very gradual onset beginning with pain and followed first by motor paralysis, and then by sensory paralysis; the symptoms being irregularly unilateral; the pain having first seemed to be neuralgic or rheumatic and burning and shooting in character; if the pain and anæsthesia in the lower limbs ascend gradually from the soles of the feet towards the trunk; and if at the same time there is a constant dull ache in a distinct segment of the spinal column accompanied by a feeling of weakness at that point, much heightened by fatigue, we have a group of symptoms pointing strongly in the direction of a neoplasm. In addition, it would be found that at first the reflexes, both deep and superficial, were much exaggerated, becoming gradually lost as destruction of the cord with descending degeneration and wasting grew more marked, the abolition of the reflexes beginning as in the case of the pain and anæsthesia in the plantar region and passing gradually upward.

Later in the disease we have the development of spasms with clonus, most marked in the intra-dural cases. The same remark is true of the symptom of rigidity. Local nutrition is not usually impaired; tenderness of the spine on percussion when it occurs in the dorsal region appears to be lower than the tumor producing it; in the cervical region, according to Horsley, this generalization does not seem to hold so closely. The feelings of stiffness and weakness will usually be found to correspond to the position of the tumor. Lateral curvature of the spine is a secondary result of the tonic spasm of the spinous muscles and therefore the concavity of the bend is on the same side as the growth. The pupils are not affected except when the cord is pressed upon above the level of the second dorsal nerve.

The age of the patient, judging from Mr. Horsley's tables, throws but little light upon the diagnosis of tumor, as we find lipomata occurring at an average age of $21\frac{1}{2}$ years, sarcomata at 18 years, ecchinococcus at 34 years, tubercle at 39 years, scirrhus and myxoma at 48 and 53 years. These figures apply to extra-dural growths. In the case of intra-dural growths we have tubercle at $18\frac{1}{2}$ years, myxoma at 43 years, fibroma

at 44 years, sarcoma at 41, psammoma at 51 years. It will be seen, therefore, that while age may be of use in eliminating certain forms of growth, as, for example, tubercle in intra-dural growths in persons beyond 30 years, it is of but little value in deciding the general question as to the presence or absence of a neoplasm.

This sketch of the principal symptoms makes a tolerably distinct clinical picture, but one which is, nevertheless liable to great variation and therefore difficult to differentiate from that of certain conditions of the cord due to causes quite beyond the reach of operation.

The chief of these, with the most obvious diagnostic points are as follows :

Spinal Hemorrhage. Intra-medullary. Onset sudden; history of traumatism, or of disease associated with profound blood changes; symptoms bilateral; pain in back; rapid disappearance of reflexes connected with the affected segment; spasms and rigidity and paralysis appear rapidly; girdle symptom; bed-sores; incontinence of feces; retention of urine very early in case; rapid course; often fatal.

Extra-medullary. Pains in limbs, spasms, etc., more marked; paralysis supervenes more slowly; course of case much slower and much more favorable.

Pachymeningitis Externa, from Caries. Common cause, caries of vertebrae; family history of phthisis, scrofula or tubercle; personal history fair; patient weak and feeble; usually history of injury also; onset slow; first symptoms often rigidity of spine, with tenderness on pressure or on tapping top of cranium, or on flexion or rotation; muscular palpitation and weakness rather than spasms or paralysis; irregular hectic fever; characteristic deformity; spinal abscess; bladder and rectum rarely affected; emaciation.

Chronic Transverse Myelitis. Frequently a history of acute myelitis; slow in onset; bilateral; first symptom apt to be an impairment of motion, ranging from paresis to an absolute paralysis; increased reflexes; ankle clonus; rigidity common, but paresis, contractions, etc., more marked than paralysis; pain in back and girdle symptom common; anesthesia and paræsthesia proportionate to motor paralysis; bladder and rectum not greatly involved; stow course.

Primary Lateral Sclerosis; Spastic Paraplegia. Often attacks robust adults between 30 and 50; slow in its onset; bilateral; begins with a feeling of weight and weakness in lower limbs, preceded by a peculiar and characteristic gait; spasm chiefly of muscles of lower extremities; manipulation of those limbs throws them into tonic spasm; paralysis not very common early; paresis with rigidity are characteristic symptoms, together with arched spine during peculiar locomotion.

Hypertrophic Cervical Meningitis. Symptoms affect chiefly the upper limbs with upper part of spine and thorax; bilateral; marked pain and rigidity involving all these regions; paralysis occurs in second stage, and affects first and chiefly arms, shoulders, etc.; no atrophy of lower extremities; no bed-sores; no bladder or rectal trouble.

These points may perhaps be better shown in the accompanying table which, however, it must be remembered, is, like the foregoing remarks, intended simply to aid in giving completeness to my consideration of the subject, and to present a sort of bird's eye view of it to the practical surgeon, who will without doubt call a neurologist to his aid in the vast majority of these cases :

Having decided in any given case that the symptoms are probably due to tumor, the interesting question, whether it is intra-medullary or extra-medullary will still remain to be settled. The best general guide will be found in the fact that the symptoms of intra-medullary growths are chiefly those of motor and sensory impairment, while the extra-medullary growths produce much more markedly irritative symptoms, as for example pain, spasms, etc. In the presence of a paralysis of gradual development, preceded by long-continued signs of nerve irritation, and with a distinct unilateral element, the transference of paralysis from one to the other limb having been effected slowly and after a considerable interval, the diagnosis of compression of the cord by some cause outside of its own structure would seem warranted. Aneurism might be excluded in the absence of the characteristic physical signs and of evidence of erosion of the spinal column; gumma would be accompanied by a history of syphilis, would often be associated with other and recognizable specific lesions, and would possibly yield to the use of iodide of potassium; a growth (cancer or tubercle) of the bodies of the vertebræ themselves usually causes a perceptible deformity. By attention to the points which I have mentioned a reasonably correct opinion may be arrived at, but I would strongly advise that in no case shall the surgeon undertake a spinal resection based on a diagnosis of tumor without having called to his aid a skilled neurologist and carefully studied the case with him. The same remark applies with even more force to the question of localization. The broad general principles, long applied in cases of traumatism, are of course equally applicable to tumors, but there are numerous refinements of modern diagnosis which belong especially to the province of the neurologist and which are of vital importance in selecting the site of operation in cases of supposed

TABLE.

	Tumor.	Spinal hemorrhage.	Causes and Pathogenesis.	External.	Internal.	Primary Lateral Sclerosis.
FAMILY HISTORY.	Of no especial significance.	Not important.	History of phthisis tubercle or scrofula.	Not important.	Not important.	Not important.
PERSONAL HISTORY.	Often perfect health up to beginning of symptoms; aneurism; scurvy or purpura. Occasionally history of trauma.	History of traumatism; aneurism; scurvy or purpura.	Health has always been poor; patient young, often under 20; history of injury; evidences of scrofula.	Occurs in middle-aged persons as a rule.	Frequently a history of acute myelitis; often a history of some form of compression; occurs in adults.	Often attacks robust, healthy adults between 30 and 50.
ONSET.	Almost universally gradual.	Very sudden.	Slow.	Moderately slow.	Slow.	Slow.
DISTRIBUTION OF SYMPTOMS.	Irregularly unilateral; especially so in intradural growth.	Bilateral.	Bilateral as a rule; may be unilateral if abscess be present.	Bilateral.	Bilateral.	Bilateral.
FIRST SYMPTOM.	Pain; insidious; very rarely sudden; neuralgic or rheumatic in character; localized; usually in the course of one nerve; sometimes felt in the spine itself as a dull ache.	Pain in back, with shooting pains in limbs if hemorrhage be extramedullary.	Rigidity of spine.	Shooting pains in back of neck, arms and upper part of chest, with rigidity of same region.	Impairment of motion or weakness in lower extremities; difficulty in emptying the bladder or obstinate constipation; numbness, "pins and needles," etc.	A feeling of weight, weakness in limbs, with slight rigidity or increase of the deep reflexes.
GENERAL COURSE OF DISEASE.	The pain is followed after a variable interval—months or years—by the development of paralysis; sometimes preceded by paresis; often unilateral in the beginning (growth); often extending from above downwards, and followed by a rapid disappearance of the reflexes.	The pain is followed by the very rapid development of paralysis in cases of intramedullary hemorrhage; more slowly in extramedullary hemorrhage. This is followed by sensory paralysis, later by symptoms of inflammatory softening and descending degeneration. Total duration of symptoms in extradural growths, about 13 months; in intradural growths, about 30 months.	The rigidity of spine is followed by the development of localized tenderness; painful flexion or rotation; pain on tapping of cranium; evidence of suppurative action; irregular muscular rigidity; irregular or spasmodic action; later the development of paraplegia.	During the first stage the pains are very severe in the upper extremities or in the head and neck; these are followed by symptoms of paralysis; but this is not tetanic locomotion; rigidity and contraction being more common; often of complete spastic nature. There are grave sensory rigidity of deep reflexes and the disturbances due to pressure on the posterior roots; paralysis, anesthesia, etc., occur later.	There is gradually increasing motor weakness, which after a time becomes development of the characteristic tetanic locomotion; but this is not tetanic locomotion; rigidity and contraction being more common; often of complete spastic nature. There are grave sensory rigidity of deep reflexes and the disturbances due to pressure on the posterior roots; paralysis, anesthesia, etc., occur later.	The first vague symptoms are soon followed by the characteristic tetanic locomotion; but this is not tetanic locomotion; rigidity and contraction being more common; often of complete spastic nature. There are grave sensory rigidity of deep reflexes and the disturbances due to pressure on the posterior roots; paralysis, anesthesia, etc., occur later.
SPECIAL SYMPTOMS.	Invariably exaggerated at first; later lost, the plantar first disappearing.	Early disappearance in the muscular area of the affected segment in intramedullary hemorrhage.	It paraplegia occurs are at first exaggerated then lost.	Increased, but especially in upper extremities, neck, below the lesion.	Always increased in parts in upper extremities, neck, below the lesion.	The deep reflexes are increased at first very markedly.
MOTUS—						
REFLEXES.						
SPASMS.	Occur in large majority of cases; ankleclonus present.	Common, especially in extramedullary hemorrhage.	Not very common; sometimes tonic spasms of proso and iliac from pressure of abscess.	Twitchings, slight spasms, etc.; most marked in muscles of arm and forearm.	Ankle clonus, etc.; same as in tumor.	Chiefly of muscles of lower extremities, which are easily thrown into tonic spasms by manipulation.
RIGIDITY.	Occurs in about one-third of cases; more frequent early with intradural growths.	Very common; appears early.	Uncommon.	Common as to neck; less frequent elsewhere.	Common.	Very marked in lower limbs.
PARALYSIS.	Constant in later stages; at first unilateral. Transference to outer limb occurs soon in extradural growths; extramedullary after some weeks or even months in intradural growths. Often involves the higher groups of muscles first.	Very common; occurs very early in intramedullary hemorrhage; more slowly in extramedullary hemorrhage.	Very far from constant.	Develops during second stage, but at first is limited to affected areas.	Usually very marked, general paresis, with rigidity, contraction, etc., being more characteristic.	Only present late in disease. Paresis and rigidity are characteristics.
SENSORY—						
PAIN.	Described as burning, shooting, etc. Almost always in the lower and more constant in limbs, ascends from the soles of the feet.	Felt in back, with shooting pains in limbs; more severe and more constant in extramedullary hemorrhage.	Felt chiefly in back or radiating to lower limbs if abscess is present.	Severe in head, neck, arms and upper part of chest.	Dull, heavy pain in back of constant.	Very little pain.
HYPERÆSTHESIA.	A zone of hyperæsthesia above the upper limit of the medullary hemorrhage; frequent and severe in extramedullary hemorrhage.	Mild or absent in intramedullary hemorrhage; frequent and severe in extramedullary hemorrhage.	Uncommon.	Very marked during first stage; confined chiefly to neck and upper extremities.	Rare.	No true sensory disturbances.
ANÆSTHESIA.	Almost constant; beginning, like the pain, in the intramedullary hemorrhage; later in extramedullary hemorrhage.	Common; occurs early in intramedullary hemorrhage; later in extramedullary hemorrhage.	Rare.	Develops during second stage, but at first is confined to areas supplied by cervical nerves.	Not often present to any marked degree; when it occurs it is proportionate to the motor paralysis.	None.
PARÆSTHESIA.	Girdle symptoms common.	Girdle symptoms common.	None as a rule.	None as a rule.	Girdle symptoms common.	Sometimes cramp-like feeling, due to spasms; no girdle symptoms.
FEVER.	None.	None.	Irregular; hectic.	None.	None.	None.
THE SENSE.	Sometimes a dull ache, localized. Occasionally localized tenderness. In a few cases a slight lateral curvature, the concavity of the curve being towards the tumor.	Possibly evidence of trau- matism; often a localized tenderness, which is often fatal or ends in complete recovery; less so in extramedullary hemorrhage.	Characteristic deformity; stiffness on pressure; inability to flex, etc.	Cervical spine may be stiff from rigidity of muscles; but there is no tenderness on pressure or percussion of the vertebral spines; no curvature.	Not noticeably affected, stiff from rigidity of muscles; but there is no tenderness on pressure or percussion of the vertebral spines; no curvature.	Often strongly affected, forward during locomotion.
NUTRITION—	Not much affected.	Not materially affected.	Emaciation.	Impaired.	Not greatly affected.	Fairly good.
GENERAL.						
LOCAL.	Decubitis, and wasting late in the disease.	Bed-sores common in intramedullary hemorrhage; rare in extramedullary hemorrhage. Muscular wasting frequent after intramedullary hemorrhage.	Muscular atrophy.	As a rule some muscular atrophy; not affecting legs.	Not greatly affected; occasionally atrophy of certain muscular groups.	No atrophy until very late.
BLADDER AND RECTUM.	Retention of urine and cystitis common. Incontinence of feces common.	Retention of urine and continence of feces common in intramedullary hemorrhage; less so in extramedullary hemorrhage.	Rarely affected.	Not affected until very late.	Not commonly affected to any marked degree until a late period—the time varying with the site of the lesion.	Usually quite normal.
PROGNOSIS.	Unfavorable. Usually death from interstitial nephritis; pyæmia from bed-sores; exhaustion from pain, etc.	Unfavorable in intramedullary hemorrhage, which is often fatal or ends in complete recovery; less so in extramedullary hemorrhage.	Fairly favorable as to life; frequently an arrest of recovery which may be complete; as a rule some atrophy and loss of power remain.	Not infrequently ends in complete recovery; as a rule some atrophy and loss of power remain.	Very unfavorable unless the case is syphilitic.	Good as regards prolongation of life; unfavorable as regards recovery; when death occurs it is usually from intercurrent bronchitis or pæmonia.
PATHOLOGY.	Lipoma, sarcoma, echinococcus, and tubercle are the most common varieties of extradural tumor; myxoma, fibroma, sarcoma, psammoma, tubercle are the most common intradural growths.	Effusion of blood into or around the cord due to rupture of vessels or to passive hemorrhage from disorganization of blood.	Cartes of vertebral bodies is frequently an arrest of recovery which may be complete; as a rule some atrophy and loss of power remain.	A chronic inflammation of the inner surface of the cerebral dura, with great thickening from the formation of new fibrous tissue.	Chronic inflammation of the whole transverse section of the cord, usually in the lumbar or dorsal region; increase of connective tissue elements.	A symmetrical section of the crossed pyramidal tracts.

tumor. Horsley's experience in the patient of Dr. Gowers is ample evidence of the unavoidable uncertainty as regards the particular vertebra or vertebræ to be attacked, but there is every prospect that these diagnoses will become more and more scientifically exact in the near future. In the meanwhile I would reter the surgeon who desires carefully to study for himself this side of his cases to the articles referred to below.¹

Having arrived at a conclusion and having decided that the probability is in favor of the existence of a tumor, and having also fixed upon its probable seat, the surgeon is confronted with the important question of the advisability of operation, and of its probable result; in other words, with the question of prognosis.

All the evidence which we now have points to extraordinary reparative power on the part of a cord which has simply been suffering from compression and to an almost equally remarkable tolerance to operative interference. The material for finely differentiated prognoses can hardly yet be said to exist, but in a general way it is safe to say that the diagnosis of tumor (if it be non-malignant) carries with it a reasonably favorable prognosis, which is strengthened if, in addition the tumor is thought to be extra-medullary.

In conclusion I desire briefly to speak of the operation itself, which has been variously described as "formidable," "appalling," "well nigh impossible," "desperate and blind," and in other similar extravagant terms. In one case the patient is said to have died upon the table from hæmorrhage; in another the operation was abandoned on account of the supposed impossibility of its completion. It has not seemed to me that these descriptions are in the least justifiable. The operation is, indeed, as was said by Dr. McDonnel, apt to be

¹Seguin on Localization of Spinal Lesions, *Pepper's System of Medicine*, vol. v. p. 77. Starr on the Localization of Functions of the Spinal Cord, *Am. Journ. of Neurology and Psychiatry*, vol. iii, 1889. Gowers, *Diseases of the Nervous System*, vol. i, p. 142. Thorburn, *The Medical Chronicle*, April 1889, p. 1, and *The British Medical Journal*, Dec. 22, 1888. Ranney, *The Applied Anatomy of the Nervous System*, p. 355. Ross, *Diseases of the Nervous System*, p. 356. Charcot, *Localization of Cerebral and Spinal Disease*. Bramwell, *Diseases of the Spinal Cord*, Mills and Lloyd, *Pepper's System of Medicine*, vol. v.

tedious and tiresome ; but, so far as any major difficulties are concerned, it is not to be compared with many much better known, and much more frequently practiced, operative procedures. I base this opinion both upon experiments on the cadaver, and upon my experience with two cases in which I have performed resection. It may be useful to give the details of the method which seems to me to be preferable :

The patient having been placed in the prone position and a gentle curve having been given the spine by means of a firm, small pillow placed under the lower ribs, a long incision should be made directly down to the tips of the spinous processes, the middle of the incision being opposite the supposed site of the tumor, the apex of the angle, or curve, if the case be one of Pott's disease, or the deformity, or displacement, if the case be one of fracture or luxation. The muscles should then be freely separated from the sides of the spinous processes and the posterior surfaces of the laminæ, the edge of a stout, thick-backed scalpel being used for this purpose. One side of the spine should be cleared and all hæmorrhage arrested by the use of hæmostatic forceps before the other side is approached, and the wound should be filled with sponges, or a towel wrung out of a hot antiseptic solution. This having been done the other side may be treated in the same manner. By the time the spine is thoroughly exposed on the second side most of the bleeding will have permanently stopped on the other ; but any distinct spirts or free oozing following the removal of the catch forceps should then be permanently arrested by ligature, after which the periosteum may be reflected by making a firm incision through it along the angle between the spinous processes and the laminæ, turning up its edge at this point with the help of dissecting forceps and then scraping the surfaces of the vertebral arches with a curved periosteal elevator. This being completed the hæmorrhage should be similarly arrested, and the periosteum reflected on the opposite side. Cline and Tyrrel used broad angular plates as retractors on each side; Gordon divided the attachment of the muscles to the articular processes, which, he said, gave plenty of room, as one end of each muscular bundle being separated from its attachment it retracted of itself and needed little holding back

with the fingers; Horsley divided the deep fascia at right angles to the line of the incision opposite its middle, in order to prevent its resisting a proper separation of the sides of the wound, and adds that it may be found necessary to divide this aponeurosis at more places than one. In my cases I found that retractors of moderate size, not large or clumsy enough to be in the way, were all that was needed to keep the muscular masses from interfering with the subsequent procedures. The next step, and one which greatly facilitates the remainder of the operation, consists in the division of the spinous processes close to their bases by means of large, strong bone forceps set at an obtuse angle. That was not done by most of the earlier operators, but certainly adds nothing to the severity of the operation while affording a much freer exposure of the laminæ, which are the next parts to be attacked. In performing these Cline advised the use of a small crowned trephine to cut through the vertebral arches, if requisite, that is, if they were not already broken into more than two pieces. Tyrrel found Hey's saw most convenient. In Gordon's case one side of the arch was broken and the yellow ligament torn through, admitting the entrance of his finger so that he merely divided the other side of the arch with a pair of stout bone forceps; Lauenstein employed a chisel; Horsley returned to the use of the trephine, but says that if more than one arch is to be removed it will be better by means of an angular saw to cut partly through the laminæ along the lines of the sides of the neural canal, and then the division of the bones can be completed with the bone forceps. I have found that both the trephine and the saw are unnecessary, and that the laminæ can be most expeditiously, and with equal safety, divided by the use of a pair of very strong bone forceps, either straight or having a large obtuse angle as may be preferred by the operator. The vertebra at the center of the incision should be selected, and the vertebral spaces above and below its lamina should be recognized with the tip of the finger. The points of the bone forceps should then be placed above and below its edges and the lamina cut through by successive short nips, the line of section being as close to the transverse processes as possible. This gives the greatest exposure of the cord and

canal, with the least risk of wounding the spinal nerves. It will be known when the section is complete by the easily recognized increased mobility of the vertebral segment which is being operated upon. The opposite side of the same vertebra is then attacked and treated in the same manner, after which the remaining ligamentous connections of the vertebra may be divided in the middle line by the same forceps, the final ligamentous attachments being separated from the under surface of the arches with a knife or a pair of curved scissors. The anatomical circumstances which make this method of operating comparatively safe are as follows:

The cord only partially fills the spinal canal and swings free in the arachnoid fluid, gravitating forward when the patient is in the prone or semi-prone position necessitated for the performance of this operation; it normally is held closer to the anterior than to the posterior wall of the canal by the anterior roots of the spinal nerves; in cases of posterior curvature and in cases of fracture or luxation the inflammatory elements which are produced tend to be in excess in the space between the posterior surface of the dura and the wall of the canal thus lessening the risk of wounding either membranes or cord. A certain degree of risk of the accident must be admitted, but it is probably at least equal, whether the trephine, the saw or the forceps are employed and would seem to be distinctly greater if a chisel or gouge be used.

Other laminæ above and below the first one may then be even more rapidly removed in the same manner, and the dura mater exposed by incising in the middle line, or, better still, gently separating, with a curved director, the thin layer of fat which sometimes covers it. At this stage much danger has been predicted by the theoretical objectors to the operation on account of hæmorrhage from the spinal plexus of veins and from the spinal arteries; as a matter of fact, however, in hardly any of the reported cases has this been alarming, and in nearly every instance it has been easily and permanently arrested by moderate pressure. At this point in the operation the appearance of the dura should be carefully noted, and the presence or absence of thickening of the connective tissue between it and the posterior wall of the canal, or of thickening

of the membrane itself. Its color should also be noted, particularly with the view of determining in cases of traumatism, whether it is or is not necessary to open it. If it be dark or purplish, from the presence of exuded blood beneath it, or yellowish from the presence of pus, it will, of course, be proper to incise it in order to empty and to explore the subdural space. My own feeling is that in all cases in the future in which this operation is performed for supposed tumor, and the growth is not found lying upon or external to the dura that membrane should be freely and fearlessly opened for exploratory purposes. The resulting escape of the cerebro-spinal fluid has been found to be merely one of the bug-bears of the subject and is certainly not to be weighed against the chance of terminating the operation without discovering a possibly existent and relievable condition. If it is determined to open it it may be picked up in the median line and at the middle of the incision with a pair of delicate-toothed forceps, nicked with a knife or the scissors and then divided either upon the director or with a pair of blunt pointed scissors to any required extent upward or downward. It can be easily and gently retracted to either side, so as to expose the whole posterior surface of the cord to both inspection and palpation, permitting the gentle insertion of the tip of the finger between its inner surface and the lateral aspect of the cord, and permitting, also, if need be, the investigation of the anterior and antero-lateral subdural spaces by means of a blunt curved instrument, such as a pedicle needle or aneurismal needle. The inspection having been completed, the tumor having been removed, the pus or blood evacuated, or it having been determined that no indication for further operative interference exists, the incision in the dura should be stitched up with fine interrupted catgut sutures. These may be introduced very readily and speedily by means of a pair of staphylorrhaphy needles, the one not in use being threaded by an assistant while each stitch is being put in place; the stitches should be inserted at intervals of about one-eighth to one-sixth of an inch, and when all are in place can be easily tied, the ends being cut off short. After this a small rubber drainage tube and a dozen strands of chromicised catgut should be laid

throughout the entire length of the wound; the muscles being then united above them by means of chromicised catgut sutures, after which the skin and aponeurosis are brought together by silk or silver wire, as may be preferred. It is hardly necessary to say that the most rigid antiseptic precautions should be observed from first to last.

Finally, I may briefly summarize the conclusions which seem to me warranted by this survey of the history of spinal operation from early times to the present day :

1st. The objections urged against operative interference in spinal traumatism were partly theoretical, hemorrhage, frequency of absolute destruction of the cord, pressure from inaccessible fragments of bone, etc., and have been shown to be unsupported by clinical facts; and were largely due to a well-founded dread of *a*, the shock, in those cases operated on in pre-anæsthetic times, and, *b*, consecutive inflammation, suppuration and pyæmia in pre-antiseptic periods. The later results, which now constitute our only safe basis for generalization, are distinctly encouraging and resections of portions of the vertebræ, in fractures, possibly even in dislocations, should be recognized as an eminently proper operation and in suitable cases altogether warranted by the facts in our possession; and further such cases are by no means rare or exceptional.

2nd. There can be still less doubt that the testimony of both pathologists and practical surgeons indicates that the cause of the paralysis of Pott's disease is in many instances an extra-medullary proliferation of connective tissue, assuming the density and proportions of a neoplasm, occupying the space between the dura and the anterior surface of the lamina, not apt to be associated with intra-medullary changes or with destructive degeneration of the cord, and very frequently removable by operation.

3rd. Every case of focal spinal lesion, thought to depend on a tumor and not distinctly a malignant and generalized disease, should be regarded as amenable to operative interference, no matter how marked the symptoms of pressure may be, nor how long continued.

4th. The method of extension as recently revived is well worthy of preliminary trial in the first two classes and in ob-

scure cases thought to belong to the third class. It has not yet been tried in a sufficiently large number of cases to establish its exact limitations, but it is unquestionably a therapeutic measure of vast importance in spinal injury and disease.

5th. It is customary and proper in deciding upon any serious surgical procedure, involving risk to life, to consider well the prospects of the patient in the event of non-interference, and to be largely influenced by them. Looked at in this light, the surgery of the spine, as regards traumatisms, caries and neoplasms may fairly be said to have a rapidly widening field, and to deserve more serious and careful consideration by practical surgeons than it has received for many years.



